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INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Article 36 and Rule 70)

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| Applicant's or agent's file reference 030887PCT | FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) | |
| International application No. PCT/JP2004/019147 | International filing date (day/month/year) 15.12.2004 | Priority date (day/month/year) 17.12.2003 |
| International Patent Classification (IPC) or both national classification and IPC INV. F01L9/04 | | |
| Applicant TOYOTA JIDOSHA KABUSHIKI KAISHA et al. | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 7 sheets, including this cover sheet.
 - This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 4 sheets.
3. This report contains indications relating to the following items:
 - I Basis of the opinion
 - II Priority
 - III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - IV Lack of unity of invention
 - V Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - VI Certain documents cited
 - VII Certain defects in the international application
 - VIII Certain observations on the international application

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| Date of submission of the demand 22.09.2005 | Date of completion of this report 26.04.2006 |
| Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465 | Authorized Officer Clot, P Telephone No. +49 89 2399-2724 |



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/JP2004/019147

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, Pages

1-19 as originally filed

Claims, Numbers

1, 3-5 received on 26.09.2005 with letter of 26.09.2005
8 received on 28.12.2005 with letter of 28.12.2005

Drawings, Sheets

1/7-7/7 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- the language of publication of the international application (under Rule 48.3(b)).
- the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- contained in the international application in written form.
- filed together with the international application in computer readable form.
- furnished subsequently to this Authority in written form.
- furnished subsequently to this Authority in computer readable form.
- The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- the description, pages:
- the claims, Nos.: 2,6,7
- the drawings, sheets:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/JP2004/019147

5. This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).
(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

| | | |
|-------------------------------|-------------|---------|
| Novelty (N) | Yes: Claims | 1,3-5,8 |
| | No: Claims | |
| Inventive step (IS) | Yes: Claims | 1,3-5,8 |
| | No: Claims | |
| Industrial applicability (IA) | Yes: Claims | 1,3-5,8 |
| | No: Claims | |

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1: FR-A-2 608 675
- D2: WO-A-03/025353
- D3: US-A-5 598 814
- D4: JP-A-59068509

1) Novelty

1.1 Any one of the documents D1, D2, D3 or the document D4 acknowledged as closest prior art in the application, discloses a valve gear of an internal combustion engine comprising the following features, commonly present in the independent claims 1, 4 and 8:

an electric motor (D1, ref.4; D2, fig.20C, ref.750; D3, ref.10; D4, ref. 25,26) a cam mechanism (D1, ref.5; D2, fig.20C, ref.710; D3, ref.16; D4, ref. 27,3) which converts a rotational motion of the electric motor into a linear motion of a valve for opening and closing a cylinder by a cam; and an electric motor control device (D1, ref.3; D3, ref.104,100; D4, ref. 22) which controls the electric motor such that an acceleration characteristic during a lift of the valve changes in correspondence to a rotation number of the internal combustion engine.

The acceleration characteristic changes according to D1-D4 in correspondence to a rotation number for the following reasons:

D1 discloses a valve gear with an electric motor driving the camshaft at a rotation speed which can be modulated for variable timing but which is basically controlled to be synchronised on a whole cycle to the rotation of the engine and set to be half the rotation speed of the crankshaft; the lift characteristic defined by the form of the cam gives for each angle of rotation of the camshaft a lift value; each angle of rotation corresponds, according to the rotation speed of the engine, to different times; the lift characteristic versus time thus defines a speed and an acceleration characteristic

during a lift of the valve which change in correspondence to a rotation number of the internal combustion engine, within the meanings of the features of claim 1.

D2 shows with reference to the actuator of fig.6 an electric motor driving a cam, which in turn axially displaces a valve. The electric motor is controlled so as to open the valve according to the acceleration characteristics indicated on curve 300 of Fig.8. The time required for the opening event being different according to the engine speed, for synchronisation of the opening event with the engine cycle, the acceleration characteristics shown at fig.8 for a given engine speed changes in correspondence to a rotation number of the engine.

D3 shows that an acceleration characteristic, the acceleration characteristic of the valve, illustrated on fig.4c for a constant motor speed, or illustrated on fig.7b according to various acceleration/speed profiles A, B and C of the electric motor shown on fig.7a changes during a lift of the valve in correspondence to a rotation number of the internal combustion engine: valve lift and timing are changed in accordance with engine speed (this change is performed in D3 as it in D1, see D1, column 1, lines 25-27); the adjustment of valve timing in correspondence to engine speed can take the form of the three adjusted valve timing profiles A',B',C' illustrated at Fig.7b, each corresponding to different valve acceleration characteristics; these profiles being moreover achieved in phase synchronisation with the engine rotation, the changes of acceleration are related to different angles -which constitute rotation numbers- within the two rotations of the crankshaft and are thus also "in correspondence to a rotational number of the internal combustion engine", within the generic meaning of this expression).

According to D4, the speed of the camshaft has like in D1 to be basically synchronized with the speed of the crankshaft, so that the lift characteristic versus time defines a speed and an acceleration characteristic during a lift of the valve which change in correspondence to a rotation number of the internal combustion engine, within the meanings of the features of claim 1.

- 1.2 None of the documents D1-D4 discloses the remaining features of claim 1, describing the specific electric motor control device which changes the motor speed during the lift of the valve to obtain different speeds of the cam according to the sections of the cam, when the rotation number of the ICE is low, the motor speed being kept constant when the rotation number of the ICE is high.

- 1.3 None of the documents D1-D4 discloses the remaining features of claim 4, describing the specific electric motor control device which changes the motor speed during the lift of the valve to obtain different speeds of the cam according to the sections of the cam, when the rotation number of the ICE is high, the motor speed being kept constant when the rotation number of the ICE is low.
- 1.4 None of the documents D1-D4 discloses the remaining features of claim 8, that "a profile of the cam being designed such as to restrict a camshaft torque at a predetermined rotation region" and "wherein the electric motor control device controls the electric motor such that an increase of the camshaft torque which is generated at a time when the cam is driven out of the predetermined rotation region in view of the profile design is restricted".
- 1.5 The subject-matter of claims 1, 4 and 8 is therefore new (Article 33(2) PCT).

2) Inventive step

Document D4, acknowledged in the description can be considered to represent the most relevant state of the art.

The problem to be solved by the present invention may be regarded as maintaining a high control accuracy of a valve gear characteristic regardless of a change of engine rotation number.

The solution to this problem proposed in claims 1, 4 and 8 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

These claims specify the control performed by the electric motor control device according to the engine speed, varying the speed of the electric motor after the begin of valve lift and after the end of valve lift, thereby restricting an increase of the camshaft torque in correspondence to the rotation number of the ICE.

None of the documents D1-D4 address or solve the aforementioned problem

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/JP2004/019147

Claims 3 and 5 respectively are dependent on claim 1 and 4 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

CLAIMS

1. (amended) A valve gear of an internal combustion engine comprising:

an electric motor;

a cam mechanism which converts a rotational motion of the electric motor into a linear motion of a valve for opening and closing a cylinder by a cam; and

an electric motor control device which controls the electric motor such that an acceleration characteristic during a lift of the valve changes in correspondence to a rotation number of the internal combustion engine,

wherein the electric motor control device controls the electric motor such that when the rotation number of the internal combustion engine is low, the speed of the cam in predetermined sections after starting the lift of the valve and before finishing the lift becomes higher than the speed of the cam in an intermediate section between the predetermined sections, and when the rotation number of the internal combustion engine is high, the cam is rotated at a constant speed during the lift of the valve.

2. (canceled)

3. (amended) The valve gear according to claim 1, wherein the electric motor control device controls the electric motor such that a difference of the rotating speed of the cam is reduced between the predetermined sections and the intermediate section in accordance with an increase of the rotation number of the

20/1

internal combustion engine.

4. (amended) A valve gear of an internal combustion engine comprising:

an electric motor;

a cam mechanism which converts a rotational motion of the electric motor into a linear motion of a valve for opening and closing a cylinder by a cam; and

an electric motor control device which controls the electric motor such that an acceleration characteristic during a lift of the valve changes in correspondence to a rotation number of the internal combustion engine,

wherein the electric motor control device controls the electric motor such that when the rotation number of the internal combustion engine is low, the cam is rotated at a constant speed during the lift, and when the rotation number of the internal combustion engine is high, the speed of the cam in predetermined sections after starting the lift of the valve and before finishing the lift becomes lower than the speed of the cam in an intermediate section between the predetermined sections.

5. The valve gear according to claim 4, wherein the electric motor control device controls the electric motor such that a difference of the rotating speed of the cam is increased between the predetermined section and the intermediate sections in accordance with an increase of the rotation number of the internal combustion engine.

6. (canceled)

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7. (canceled)

8. (amended) A valve gear of an internal combustion engine comprising:

an electric motor;

a cam mechanism which converts a rotational motion of the electric motor into a linear motion of a valve for opening and closing a cylinder by a cam, a profile of the cam being designed such as to restrict a cam shaft torque at a predetermined rotation region; and

an electric motor control device which controls the electric motor such that an acceleration characteristic during a lift of the valve changes in correspondence to a rotation number of the internal combustion engine,

wherein the electric motor control device controls the electric motor such that an increase of the cam shaft torque which is generated at a time when the cam is driven out of the predetermined rotation region in view of the profile design is restricted.